Review Article

Smart Hotel Security: Integrating AI for Advanced Safety Solutions

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Abstract: Security systems are essential for hotels and lodging services, considering that this lodging service is a service that is intended for all people from various circles and from anyone who comes from various places, this is very common and dangerous, in terms of security and comfort. Several security systems are built by hotels, such as CCTV and security systems on doors and various security system techniques such as retina, fingerprint, RFID, and various security techniques. Not only at the door but safety boxes are made with various locking techniques from a combination of numbers. In addition to hardware, software with enhanced capabilities in Artificial Intelligence can also be applied such as face detection, predictive analysis, and automated surveillance. The combination of hardware such as Jetson Nano and software can be improved to build AI-based security systems in creating security systems in hotels that can be built professionally and smartly. Some methods developed in the face detection system of a person trying to enter a hotel room to commit theft, for example, are using Convolutional Neural Network (CNN). The developed system can detect predictions of age, gender, and other parameters.

Keywords: Artificial Intelligence (AI), Hotel Security, Smart Security Systems, Facial Recognition, Predictive Analytics

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1. Introduction

Hotel security systems are essential today, in addition to maintaining the comfort and safety of hotel guests, also the security system at the hotel can make the hotel win the competition to become a contemporary hotel that applies Artificial Intelligence (AI) technology which includes current sophistication, which makes added value to the hotel and its attractiveness. Some security systems that involve not only CCTV videos but AI are super-precise facial recognition systems ranging from age, gender, and also other parameters. Not only in AI-based software development, but also in sophisticated hardware such as the Jetson Nano Microprocessor, Raspberry Pi 5, and other devices that can be developed and synergized into a sophisticated prototype.

Furthermore, some super-precise face detection methods [1,2,3] use methods such as Convolutional Neural Networks (CNN) that can be processed with several human face datasets, perform the training process and run the program coding. Some software or programming languages or entrepreneurs such as Python continue to be developed with libraries that are free and continue to be developed by software developers and coding, but like paid programming languages such as MatLab are also not inferior, by developing several libraries but not free, this is because of the license that protects it.

Moreover, this article is a review article to look back and try to approach a detailed analysis of the library's approach to tracking crimes that could have occurred in hotel rooms or areas around the hotel such as the lobby or the side or outside of the hotel which with CCTV still cannot maximize it. Some methods such as Super Resolution using CNN have been able to make estimates and draw conclusions from the perpetrators of crime and track them. In this case, technology has been able to be applied to help the authorities or police in facilitating the tracking process. Face detection can also be applied to traffic systems, such as showing on a large screen at a red light that a rider is not wearing a helmet for example.

Moreover, Perhaps in a more detailed process, the face of the unhelmeted rider is instantly linked to the police database, that he is named '*A*', with his driver's license number, and address. The system can accumulate violators in one day in a database and also the fines given to violators and everything automatically.

2. Theory

2.1 Comparison of face detection methods

Several methods are used in the face detection process for improving security systems [4,5,6] in hotel or lodging areas such as the Haar Cascades method, Histogram of Oriented Gradients (HOG), Deep Learning (Convolutional Neural Networks - CNNs), Multi-task Cascaded Convolutional Neural Networks (MTCNN), RetinaFace, and YOLO (You Only Look Once) [7,8,9,10].

Moreover, from the comparison of Table 1, there are several parameters such as Speed (ms), accuracy (%), Implementation Complexity, and Required Resources. In Table 1, it can be seen that the method with high speed and accuracy is the best method that can be applied in the process of reading or predicting Face Detection. However, the accuracy and other parameters are not significant but can be adjusted to the various projects that are being worked on and completed. YOLO, for example, has good specifications and implementation of face detection software [11,12,13,14] that is often applied in practical application projects. Some methods that can be developed together with software developers will provide benefits in improving the specific capabilities of the software. Developers can share various 'bugs' and problems that occur in the software development process and can be solved together with the community that is incorporated in it and provides complete sources starting with step-by-step how to solve the problem, sources such as libraries, code, etc.

Table 1. Comparison of face detection methods

Methods	Speed (ms)	Accuracy (%)	Implementation Complexity	Required Resources
Haar Cascades	50 - 100	70 - 80	Medium	Low
HOG	100 - 200	80 - 90	High	Medium to High
CNNs	100 - 300	95 - 99	Very High	High
MTCNN	150 - 250	95 - 98	High	High
RetinaFace	200 - 400	96 - 99	High	Very High
YOLO	45 - 150	90 - 95	Medium to High	Medium to High

3. Method

In this research, the methods are described in a flowchart such as the Motion Detection Method, and detect suspicious movements at a certain time or frame, for example again, face detection [15,16,17] by detecting the face of a person of a certain gender and their approximate age. In this research, the method is shown first using Pseudocode and also a Flowchart, or block diagram to make it easier for readers to understand the flow of this article review.

3.1 Pseudocode

This research review provides a Pseudocode example of processing from CCTV at the front of a hotel or inn, with a suspicious person going back and forth intending to steal a motorcycle. This is one of the activities processed using MATLAB Software into a Motion detection and analyzes how long the same movement is in the same place. This is one analysis of an increase or improvement in the security system, namely CCTV in the area outside the inn or Hotel. Pseudocode 1 shows an example of the initialization of a coding for motion detection. Pseudocode 2 is the Loop for Video Processing which will then be analyzed.

```
LOAD video
SET threshold = 25
SET frameRate = video.FrameRate
SET movementDuration = []
SET motionDetected = false
SET timeCounter = 0
```

Pseudocode 1

```
WHILE video has more frames:
    READ current frame
    CONVERT current frame to grayscale (frameGray)
    IF previous frame exists:
        COMPUTE motion = abs(current frame - previous frame)
        COMPUTE motionBinary = motion > threshold
        IF motion detected in motionBinary:
            IF motionDetected == false:
                SET motionDetected = true
                SET timeCounter = 1
            ELSE:
                INCREMENT timeCounter
        ELSE:
            IF motionDetected == true:
                SET motionDetected = false
                APPEND (timeCounter / frameRate) to movementDuration
                RESET timeCounter
    SAVE current frame as previous frame
    DISPLAY frame and motionBinary
```

Pseudocode 2

3.2 Flowchart System

The system flowchart shows a way of working that is used so that the AI system, in this case, the video motion analysis process, can be analyzed appropriately. Get how many frames are created, time or duration (second), and other parameters that are essential for decision-making. Figure 1 is a Flowchart of motion detection on the security system analysis development approach.

In this article review, we will look at several human movements that can be analyzed using only a Smart Camera or image or video processing with various smart methods. Several algorithms can be applied to analyze images or videos. The movement of a person can be analyzed for several frames of movement and concluded to be a suspicious movement or a normal movement using a certain algorithm. In addition to using image processing algorithms, Histogram of Oriented Gradient (HOG) is also used. The HOG method is used to detect and track object movement in this case human movement in a video, HOG works by analyzing the direction of the gradient intensity around the image or frame. Feature recognition then makes it possible to learn about specific environmental conditions and also determine whether a situation is considered normal or not. Object and face recognition can finally be optimized by verifying and classifying which faces are considered suspicious objects and which objects are not suspicious or safe [18,19,20]. AI cameras can also be developed for alarm systems, not only providing object classification about humans specifically on gender, and approximate age, but can also be paired with actuators for faster preventive action. AI cameras that are enhanced with intelligent server integration systems will be able to provide fast response time in tracking.

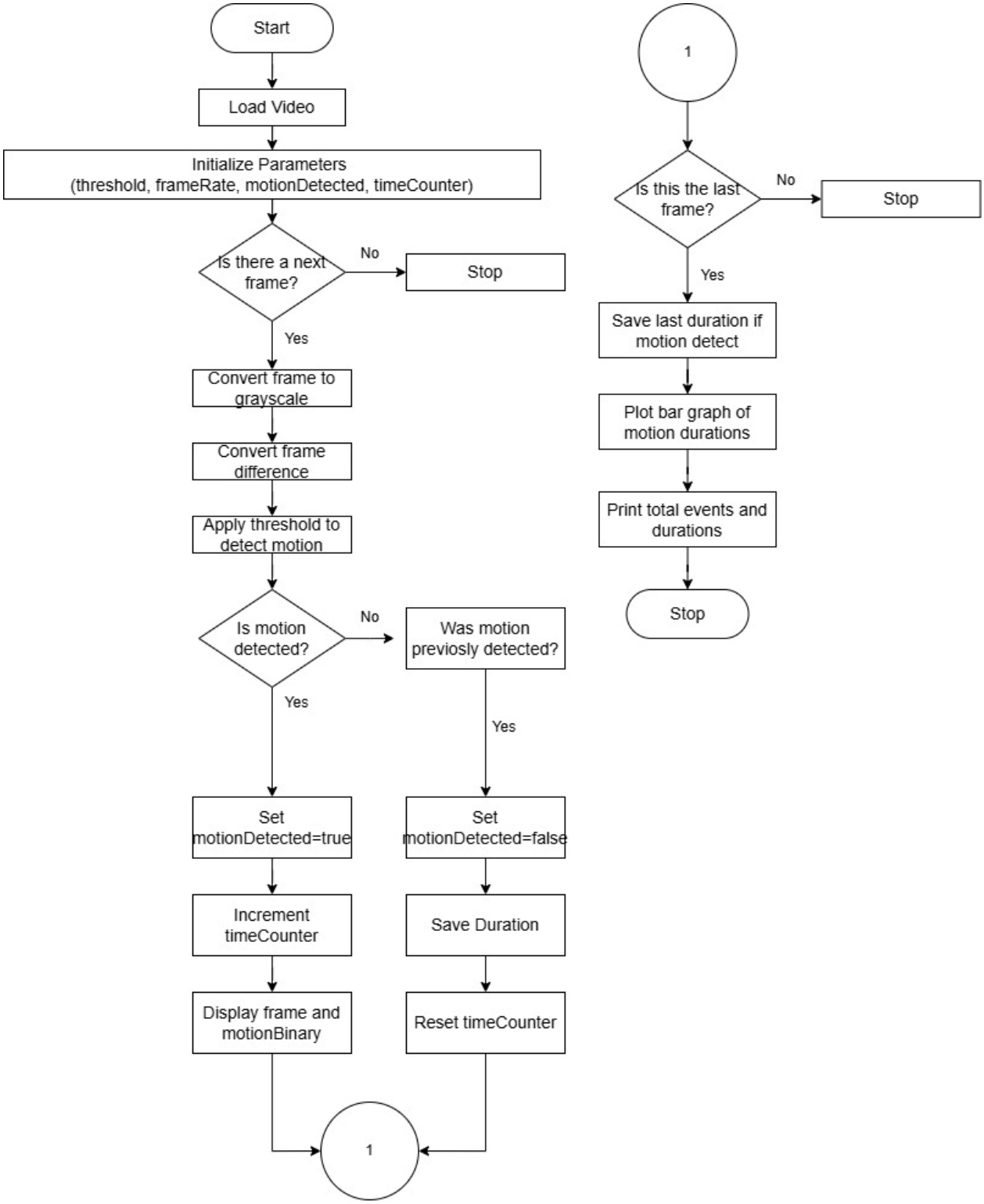

Figure 1. Flowchart of motion detection on security system analysis development approach

4. Discussion

4.1 Face Detection, an analysis for CCTV development in a hotel area

The most important thing in the intelligent system is object recognition first. After the system recognizes objects, for example, various types of human faces, then the system is said to be successful, or AI states that it has recognized faces with precision, for example from the estimation of age, gender, maybe even estimation of people from certain continents and countries.

Furthermore, the next step is an automatic face detection system, which using AI can use Matlab or Python Code with CNN or other methods, the face can be detected as in the figure above. Any precise face detection process depends on the complex dataset as well as the algorithm applied. Figure 2 is an example of several faces of various types that can be developed in detail using certain methods such as CNN to specifically detect each face is shown in Figure 3. More specifically whether the photo is smiling angry or normal can be seen in Figure 4.

Figure 2. Different types of people's faces

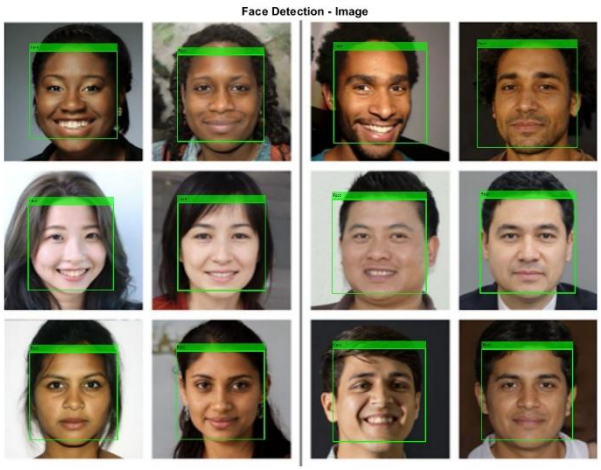

Figure 3. Face Detection specialized in human faces

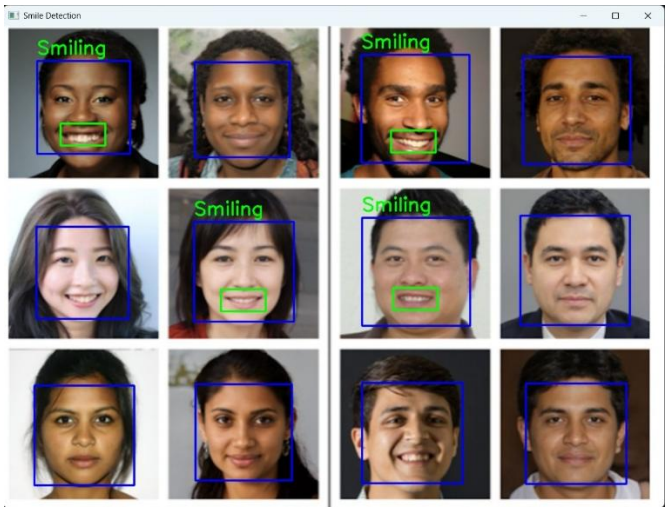

Figure 4. Smiling detection

Furthermore, an intelligent system can also classify images based on the number of successful face detections with classifications such as gender, estimated age, country of origin or race, and other factors or parameters, such as the following graph shows how many faces are detected, the development is how many faces are smiling or happy, sad, or other facial expressions.

Then in a more in-depth manner, the pictures of several people in Figure 3 can be developed to distinguish those who are laughing or happy from those who are not. The development is how many percent of the smiling level, whether 100%, 75%, 50%, or only 25% smiling, this can be developed again with the development of coding using Python Programming.

Moreover, to improve the analysis process, smiling can also be analyzed in terms of the percentage of happiness. This needs deep processing. Then what does it have to do with suspicious actions at the Hotel? A smile is one of the right ways to be applied to the staff at the Hotel such as receptionists. But a smile with a face that is not consistent or precise with a smile can also be suspected as a strange act and needs to be suspected, considering that hotels are very important public places and many people from various places meet and may have interactions. With configurations and specifications in programming, able to combine various face shapes with various expressions that can be applied to hardware and testing using smart cameras and actuators. An example of the analysis results is shown in the following graph. Where smiling and not smiling can be distinguished so that it can be calculated how many percent are smiling.

Furthermore, Some methods that are specific to face detection include Haar Cascades, Histogram of Oriented Gradients (HOG), Deep Learning (Convolutional Neural Networks - CNNs), Multi-task Cascaded Convolutional Neural Networks (MTCNN), RetinaFace, and YOLO (You Only Look Once). We can compare each of these methods for specific and slightly complicated projects. For example, to determine an image that is blurred and not visible in a high-resolution image, detect a specific image or photo, or give a conclusion of what object is detected. Detection is done in the area or coverage of cameras such as humans or animals along with their complete attributes, such as age, gender, and their feelings whether they are happy, angry, joyful, sad, and so on.

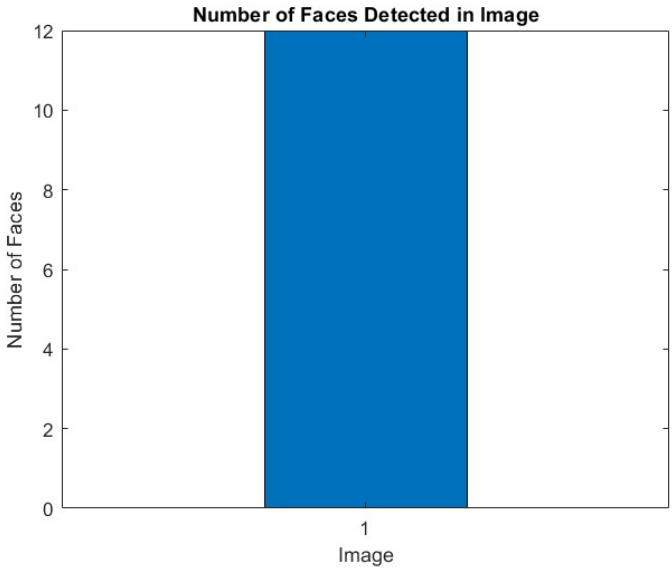

Figure 5. Number of Faces Detected in Image

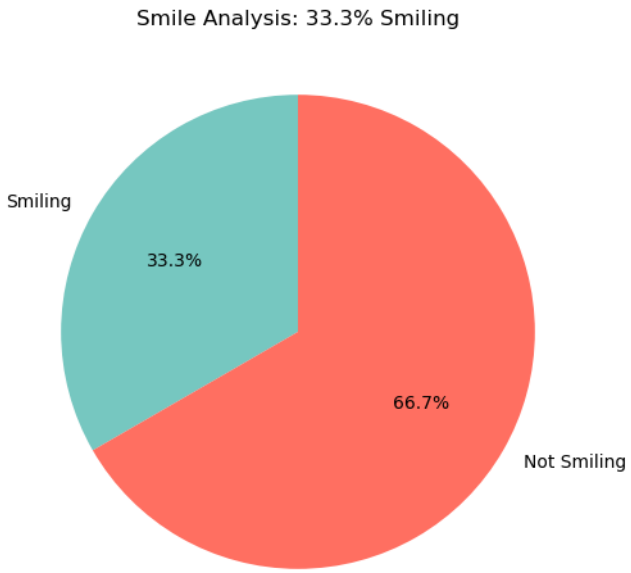

Figure 6. Smile Analysis

4.2 *Suspicious Movement*

The next analysis is to find out how long a person stays in the same place and even paces in the same place with the aim at a certain point. In this video, the target is a motorcycle on the side of the road. Although it is not used as a foundation for the truth about theft, it could be that the person is the owner of the motorcycle, but the percentage of the possibility of theft is classified as a large percentage.

Figure 7. Motion Duration at the Same Place

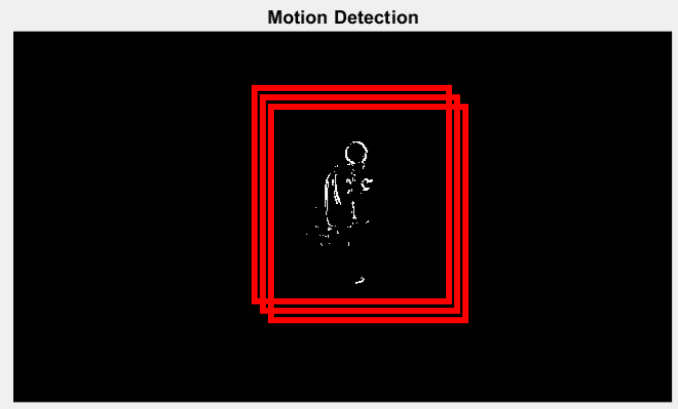

Figure 8. Motion Duration at the Same Place

Furthermore, specifically, the duration (seconds) can be seen in detail in an analysis graph shown in Figure 7. The graph represents an activity where the larger the event number, the greater the activity in the same area shown at any given time.

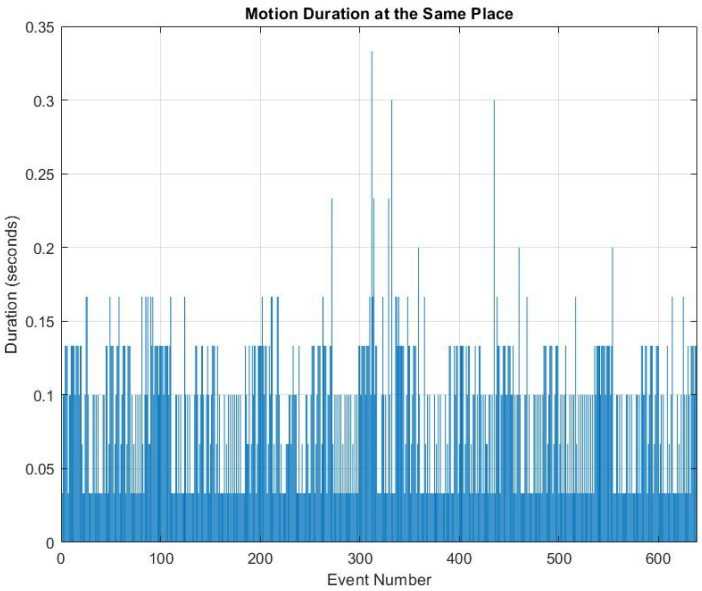

Figure 9. Motion Duration at the Same Place

The next development is to know about gender or age, and other parameters that can be known by a photo or video of someone suspicious in the area of hotels, inns, or other essential public places. Some of the components used to work on image processing in Python use several libraries. One of the libraries or modules is cv2. cv2 is a Python module from the OpenCV (Open Source Computer Vision Library) library that is used for computer vision and image processing.

4.3 Smart Door for Hotel

Furthermore, the next security system is located in Hardware, in this case, the doorknob or door of the hotel. How to build a smart hotel door, here requires the role of technology, for example, eye retina detectors or at least face detectors to recognize the faces of visitors or hotel room tenants specifically, precisely, and accordingly. Then what components are needed? In building hardware and software, a combination of both, and also its application, a complex system, programming language and coding, library, and module that can be applied very well to be developed properly and precisely. Until it produces an output that can provide the right decision making as shown in Figure 10, namely a warning that determines how the smart door works. That is, from the input of a person's face that matches the database.

```
[INFO] Sistem Smart Door aktif. Mendeteksi wajah...

[INFO] Wajah terdeteksi: Unknown
[ALERT] Wajah tidak dikenali. Pintu tetap terkunci.
```

Figure 10. Action from a smart hotel door

4.4 CNN Analysis

Furthermore, for the application of CNN, we can use available datasets such as MNIST, first install Tensorflow, and also Keras in Python. Accuracy and Loss results can be seen in Figures 11 and 12. An example of this analysis result is given as one of the characteristics of CNN in performing detailed analysis on an image or photo, namely the comparison between accuracy and val_accuracy or the comparison between accuracy and epoch, as well as the comparison between loss and val_loss shown in Figure 12 or the comparison between loss and epoch.

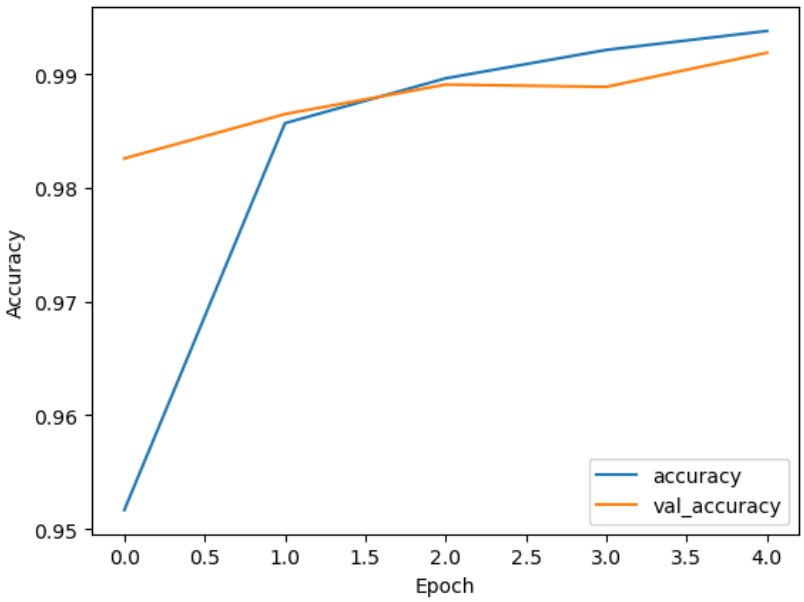

Figure 11. Accuracy vs Epoch

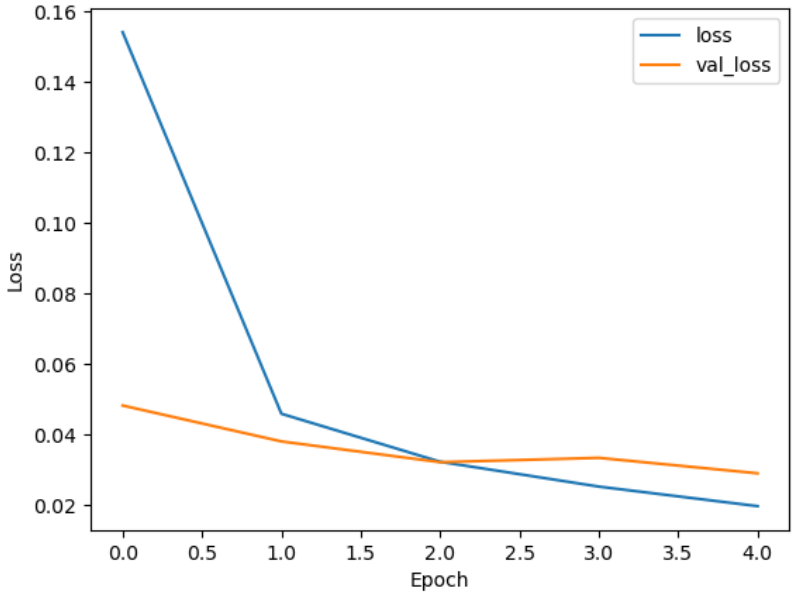

Figure 12. Loss vs Epoch

4.5 Comparison of Face Recognition Methods

Comparison of Face Recognition methods has advantages and disadvantages between methods, for example, Haar Cascades, HOG, CNNs, MTCNN, RetinaFace, and YOLO. Of these methods, CNNs is a Deep Learning Method that has high accuracy compared to other methods even though several other methods also have high accuracy, only Haar Cascades has an accuracy value below 80%. However, this is also still an approach, not used as a benchmark or certainty that Haar Cascades is a bad method. Moreover, when viewed from Frames per Second (FPS) in Figure 14, a good Face Recognition method is YOLO. YOLO has an FPS of 30 FPS then CNNs with 25 FPS, then the lowest of the other methods is Haar Cascades at 15 FPS, this shows the FPS value.

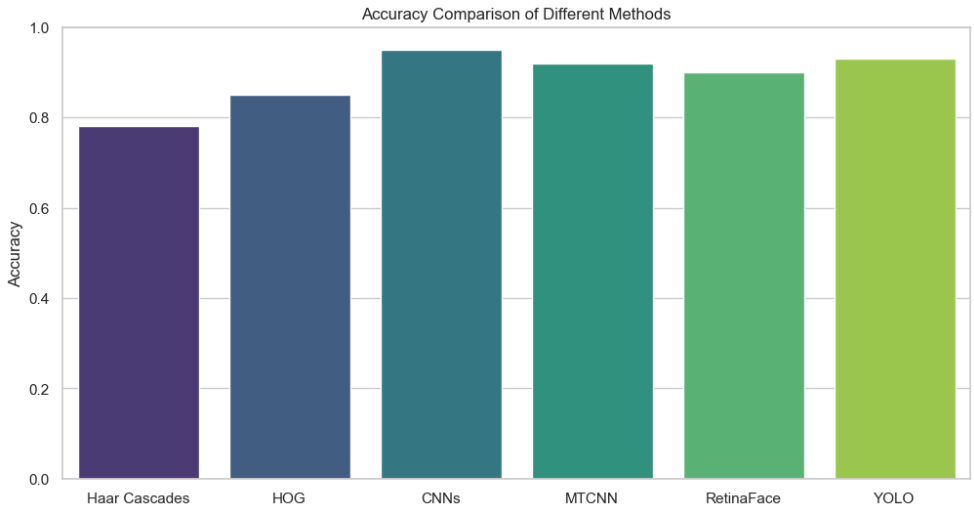

Figure 13. Comparison of the ability of face recognition methods in terms of accuracy

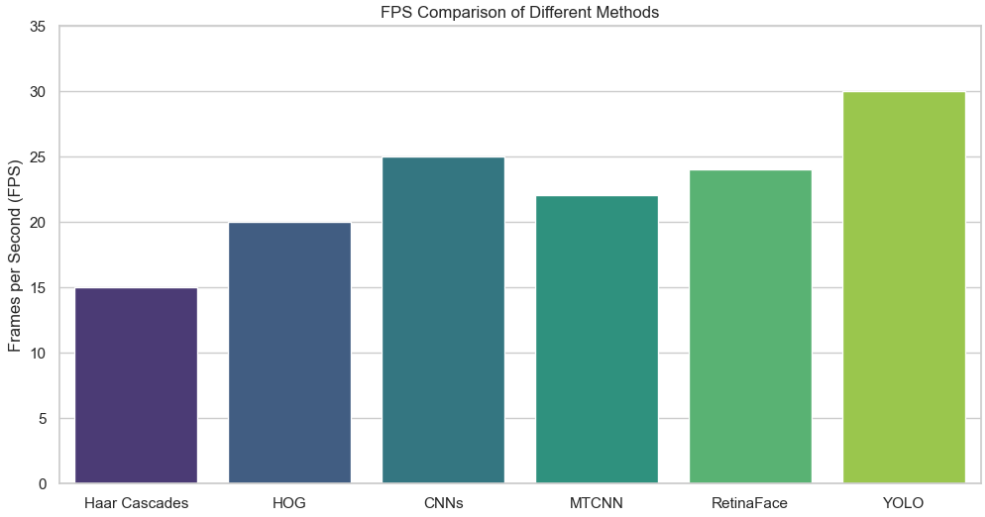

Figure 14. Comparison of the ability of face recognition methods in terms of FPS

5. Conclusion

Security systems in hotels can be built from various sides starting from improving software and hardware, from the software side, it can be built with facial recognition patterns using Artificial Intelligence and methods such as Convolutional Neural Network (CNN) and other methods. The analysis of the security system at the hotel can be seen from the recognition of a person's suspicious movements while walking around the hotel, an attempt to open the hotel door, and also other suspicious actions. The specific comparison for the CNN analysis example using the MNIST dataset is the comparison between accuracy and loss, and the expectation is that there is no significant difference between accuracy and val_accuracy, and also loss and val_loss. Comparison of face detection methods such as Haar Cascades method, Histogram of Oriented Gradients (HOG), Deep Learning (Convolutional Neural Networks - CNNs), Multi-task Cascaded Convolutional Neural Networks (MTCNN), RetinaFace, and YOLO (You Only Look Once) will make more specific reading and analysis systems to strengthen the AI-based smart camera side that can be produced in the form of hardware that has the capability of tracking systems in the future.

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